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Evaluating macroeconomic strategies with a calibrated model¹

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Abstract

In several catching-up EEC countries we experience an expenditure boom explained by arguments referring to intertemporal consumption optimization. We have calibrated a model assuming externalities from foreign direct investments and country risk premium dependent on the debt/GDP ratio. In the model the internal rate of return of marginal saving turned out to be about 18 percent, higher than the level that any estimate of the time preference might justify. Its existence is due to the fact that externalities produced by both saving and investment are not internalized by private agents. Fiscal policy should make the necessary adjustments to approach optimum.

1 Introduction

After a long period of transformational recession CEE countries seem to enter a new phase of development, the catching-up to the rest of Europe. Having recognized this development many politicians and partly in response to the political campaigns many citizens start to feel that after a successful political and economic system change time has arrived for a "welfare system change". People suffered enough from the recession caused by reforms, it is time to consume more now. As most countries have no net external reserves to use up – on the contrary, Hungary for example has started the transformation with large debts – the source of excess consumption could be future output. This future high output, the prospect of a fast catching-up process is the main argument that incites people into an exuberant demand for higher wages and higher consumption.

The rationality of such an intertemporal reallocation of consumption depends on the time preference of consumers. We do not dare to tell the numerical value of this preference either in the aggregate or for individuals. What we try is to calculate the opportunity cost of switching future consumption to present consumption. Or putting in another way, we try to determine the real return of aggregate saving around the present level of net saving in Hungary. Although we had Hungary in mind when calibrating the model, the differences among CEEs is not as large that our qualitative conclusions would not hold for other countries in the area as well.

The lessons to be learned from the simulations of the model are related to fiscal policy. Our assumption is that foreign capital in Hungary – similarly to other catching-up countries – has a positive external effect on productivity. Similarly, personal or government savings have a positive external effect on the risk premium component of interest rates. Therefore the decentralised decisions of agents will not lead to an optimum and fiscal policy has the task of correcting the market failure. This correction has obviously target a higher stock of resources that produce the externalities. Our model does not give a recipe on what tools and to what extent should be used to correct the market. Basically the government can influence intertemporal allocation in two ways: using the tax structure and – in a non-Ricardian world – making savings itself. In our model these tools are not specified. We do not model how the tax system affects consumption² and how government savings affect aggregate savings. In addition, we do not

²Valentinyi (2000) analysed the effect of the tax system directly on the catching-up process. His model differs from

consider any other effects of fiscal policy on output. We know for example that fiscal debt has distortionary effects on future working incentives that may lead to future losses of output.³ We add only one element to the evaluation of fiscal policy. This element is based on the fact that whatever the channel that fiscal policy uses in correcting market failures, governments have to give account whether they did their job well. As a yardstick of their performance might be the social opportunity cost that society faces as the consequence of personal and government choices.

In Chapter 2 we give a verbal description and justification of the main assumptions, in Chapter 3 we present the equations, in Chapter 4 the simulation results and in Chapter 5 the conclusions.

2 Main assumptions and features

The model is classical, assuming market clearing. The economy is a small open economy where capital flows are unconstrained but their speed is dampened by adjustment costs. Tradables and non-tradables are distinguished in an implicit way. The model is classical, the price level is not determined, variables are in real terms, the real exchange rate is the price of non-tradables in terms of tradables, normalized with the similar ratio abroad.

The catch-up process is modeled the following stylized way. Labor supply is constant – more or less in accordance with actual demography. The growth rate of total factor productivity (TFP) is equal to the world rate in the long run. During the catch-up period the additional growth originates partly from capital accumulation and partly from an additional TFP growth arising from externalities produced by the inflow of foreign direct capital.

The speed of the catching-up process depends on the speed of the capital accumulation process. The capital stocks (foreign and domestic) reach their steady state anyway, but the speed depends on the country risk premium and the path of the real exchange rate. The higher the country risk and weaker the exchange rate the faster will be the capital accumulation.

ours as he does not assume externalities and the catching-up process consists of an accumulation of real and human capital.

³The literature is too rich for referring to it. Blanchard (1990) summarises the problem in a simple model, Alesina–Ardagna (1998), and Perotti (1999) are some of the recent empirical works on the topic.

2.1 The Externalities of Foreign Direct Capital

The external effect of FDI is various. Separation of these effects is difficult but we might distinguish two kinds.

1. The agglomeration effect is a well-known concept of regional economics. Economic growth is not smooth geographically, because geographic concentration brings savings (savings in transport, communication, or other transactional or informational costs) in production and sales.⁴ This means that each investment improves the profitability of the next entrant, i.e. it produces externality. This phenomenon exists independently from the originating country of investment. Foreign direct investment flows adds to this externality only by their *net* value.

2. In a catching-up country FDI may incorporate a higher level of know-how. This know-how does not remain within the firm but spreads through contacts with other firms: suppliers will be trained or forced to a quality and discipline that comes with the higher production culture of the entered foreign firm. This external effect – in contrast to the agglomeration effect – depends on the *gross* inward flow of FDI.

We do not model the agglomeration effect, the productivity effect of this process is considered in the exogenous TFP term of the production function. We model only the external effect of FDI as free supplier of know-how.

It is clear that with an increase in the share of foreign capital the know-how supplier effect of foreign capital diminishes. We reflected this feature in our model by specifying the production function in a way that with approaching to the steady state the external effect of FDI approaches 0.

⁴See Krugman (1990) and Venables (1996)

2.2 The Saving-Investment Link in the Open Economy

In the introductory economics textbook version of the open economy model with the opening up of capital markets the period-by-period budget constraint that establishes the link between consumption and investment disappears and the two flows become more independent. We know that capital markets are not perfect and therefore a strong separation of the two systems is not justified.⁵ Risks, information constraints and adjustment costs create virtual walls across countries. Capital adjustment is not only gradual, but it does not lead to an equalization of returns either. Country returns contain differing country risk premia. This premia depend on the same factor that influences return in closed capital markets: the level of savings. This brings us back to the feature of the closed capital market economy.

Saving behavior affects the return on capital through two channels: (a) in the medium run a drop in demand weakens the real exchange rate (and decreases the real interest rate) (b) a decrease in the debt level decreases the country risk premium

Let us see these two factors in more detail.

2.3 Demand and the Real Exchange Rate

The idea of the concept of real effective equilibrium exchange rate⁶ builds on Dornbusch (1980) saying that an increase in demand makes relative costs of non-tradables higher because tradables demand is met by imports while output has to switch to non-tradables to meet increased demand. This means that the real exchange rate increases. Because of the real interest rate parity this means a higher interest rate. This way an increase in consumption crowds out investment like in the closed capital market economy.

This feature is included into our model but it works only in the medium run. In the long run the real exchange rate is independent from demand. In the long run relative costs in the non-traded sector will not increase because there are no sector-specific production factors by assumption allowing that factor flows equalize relative returns across sectors at the starting rates. This adjustment process leads to purchasing power parity (PPP) or the Balassa-Samuelson path

⁵See Feldstein-Horioka (1980) for the first demonstration of this "puzzle".

as the more general case.⁷ The half-life of the adjustment process is about 4-5 years according to the "international consensus" view.⁸

This way our model combines the PPP and the "sustainability" approach to the equilibrium real exchange rate. The difference between the two approaches lies in the assumption about the speed of adjustment of production factors. The sustainability approach considers the convergence to PPP too slow to take into account at all. In our approach the half-life of 4-5 years is too short to be disregarded. As a consequence the real exchange rate and the trade balance are related only in the medium run, while in the long run PPP (Balassa-Samuelson equilibrium) holds.

Stein (1999) defines a concept of long-run equilibrium real exchange rate in his NATREX⁹ model. In this definition in the long run capital stock is in steady state equilibrium. This definition would be useful for conclusions about the real exchange rate only if the adjustment process of capital stocks would be faster than the adjustment process of production factors across tradable and non-tradable sectors. Otherwise PPP is the long-run equilibrium. Economic history shows that the processes that lead to debt accumulation are very slow, they may take decades.¹⁰ The process towards PPP may be slow, but in any case faster than this.

We calibrated the model to take these differences in the speeds of adjustment into account. This way a fiscal shock appreciates the real exchange rate in the short run, in the long run however – in contrast to the NATREX model – the rate is determined not by the drop in demand because of the debt burden but the convergence process to the Balassa-Samuelson path. In the long run there is no direct interaction between net exports and the real exchange rate. If demand depreciated the real exchange rate, this can happen only because the accumulated debt leads to a higher country risk interest premium, this suppresses investments and the suppressed foreign component of investments effects TFP and the real exchange rate through the Balassa-

⁶See for example Faruquee (1995), Stein (1999).

⁷According to the Balassa-Samuelson hypothesis productivity in the tradable sector increases faster than that in non-tradable sector and the gap between the productivity rates depends on the rate of aggregate productivity growth. Therefore the real exchange rate of fast growing economies increases.

⁸See Rogoff (1996) about the international consensus.

⁹NATREX (Natural rate of equilibrium exchange rate) and the similar concepts is based on the classical assumption of 0 output gap (called internal equilibrium) and the equilibrium real exchange rate is defined as the common slope of the production possibilities frontier and the utility function. While these models consider the strictly convex production possibilities frontier as given even in the long run, in our model the elasticity of substitution between sectoral outputs becomes infinite in the long run.

¹⁰A formal model for this behavior is given in Simon-Várpalotai (2001).

Samuelson effect.

2.4 The Country Risk Premium

As discussed before, the existence of country risk constrains the wedge between consumption and investment in a country, partly taking over the role of the instantaneous budget constraint. This allows the interest rate and capital returns to differ from international rates permanently, preserving the feature of the closed economy Ramsey-model that impatient consumer behavior leads to a lower steady state capital stock and output.¹¹

The country risk has to be an important issue in macroeconomic policy as individual risk taking renders negative externalities.¹² Each borrower adds to the country risk premium but the cost of additional risk caused to others is not internalized in her own calculations. Macroeconomic policy has the task to correct this market failure.

Before discussing the calibration of the effect of risk let us make some remarks about the nature of the risk premium before and after joining the currency union. Indebtedness leverages an economy and thus magnifies the relative variance of her income. For foreign investors who sell in the country this means a higher demand risk and accordingly a higher revenue risk. For lenders of financial assets this means a higher default risk and exchange rate risk.

By joining the currency union the currency risk disappears but the leverage of the economy does not change. The total risk depends on whether the flexible exchange rate system itself added to aggregate risk or not, was it a stabilizing or a destabilizing factor in the economy. We do not take up this issue for discussion. In the model we take a middle road by assuming that the total risk of investments does not change by this system change. Technically we do not distinguish between financial investment risk and direct investment risk but all the risks are considered simply as a source of interest rate premium. In case of modeling the effect of the currency union we had to give account of the distribution of risk between financial and physical capital.

¹¹In our model the risk of higher consumption today is taken into account only as a country risk premium which means practically a default risk. The risk for the consumer should have been specified in the consumption function, if we had used a structural formulation.

¹²See Harberger (1986).

3. Model Equations

As our model describes an infinitely growing economy, we normalize growing variables by output. This way we analyze the path towards the steady state of the rates of variables to output. Normalized variables are given in small letters while steady state values are denoted by a bar above the variable.

3.1 Output

Output is determined by a homogenous at first degree Cobb-Douglas production function:

$$Y_t = A_t K_{f,t-1}^{\alpha_f} K_{d,t-1}^{\alpha-\alpha_f} L^{1-\alpha},$$

where L labor supply is fixed ($L=1$), K_f and K_d are foreign and domestically owned capitals, A_t productivity, including the external effect of foreign capital ratio:

$$A_t = A_0 (1 + \mu_{tfp})^t e^{\gamma \frac{K_{f,t-1}}{Y_{t-1}}},$$

where A_0 is a scaling factor of output, μ_{tfp} is the exogenous constant component of TFP growth, and $e^{\gamma \frac{K_{f,t-1}}{Y_{t-1}}}$ is the output generating externality implied by the ratio of foreign owned capital.¹³ For the sake of easier calculation we transformed capital stock variables to rates:

$$Y_t = A_0 (1 + \mu_{tfp})^t e^{\gamma k_{f,t-1}} k_{f,t-1}^{\alpha_f} k_{d,t-1}^{\alpha-\alpha_f} Y_{t-1}^{\alpha} L^{1-\alpha}. \quad (D1)$$

Growth rate of output:

$$g_t = \frac{Y_t - Y_{t-1}}{Y_{t-1}}. \quad (D2)$$

The change in Y_t/Y_t^w the output level relative to the world depends on the difference between g_t domestic and g^w (assumed constant) world growth rates:

¹³We can easily check that the production function is homogenous at first degree by multiplying the explanatory variables by a constant.

$$Y_t / Y_t^w = \frac{1 + g_t}{1 + g^w} Y_{t-1} / Y_{t-1}^w. \quad (D3)$$

3.2 Capital Accumulation and Investment

Equations for capital accumulation are standard, where δ is the depreciation rate.¹⁴

$$k_{f,t} = \frac{1 - \delta}{1 + g_t} k_{f,t-1} + i_{f,t} \quad (D4)$$

$$k_{d,t} = \frac{1 - \delta}{1 + g_t} k_{d,t-1} + i_{d,t} \quad (D5)$$

The dynamics of $i_{f,z}$ and $i_{d,t}$ investments is described in the spirit of Tobin-q theory similarly to a model with quadratic adjustment costs $(\Psi(i, k) = i + \beta_k \frac{i^2}{2k})$. Accordingly investments positively depend on profits over alternative returns cumulated into the future ($\Pi_{f,t}$ and $\Pi_{d,t}$)

$$i_{d,t} = \frac{\Pi_{d,t}}{\beta_{kd}} + \frac{\delta + \bar{g}}{1 + \bar{g}} k_{d,t-1} \quad (D6)$$

$$i_{f,t} = \frac{\Pi_{f,t}}{\beta_{kf}} + \frac{\delta + \bar{g}}{1 + \bar{g}} k_{f,t-1}, \quad (D7)$$

where $\frac{\delta + \bar{g}}{1 + \bar{g}} k_{d,t-1}$ and $\frac{\delta + \bar{g}}{1 + \bar{g}} k_{f,t-1}$ are parts of investment that maintain an unchanged capital-output ratio at \bar{g} growth rate.

3.3 Consumption

We use a reduced form equation for describing consumption behavior. c_t consumption is a linear function of y_t^{lab} labor income and w_t net wealth. This functional form is standard in econometric

¹⁴Written in level form: $K_{f,t} = (1 - \delta)K_{f,t-1} + I_{f,t}$. Dividing by Y_t : $\frac{K_{f,t}}{Y_t} = (1 - \delta) \frac{K_{f,t-1}}{Y_{t-1}} \frac{Y_{t-1}}{Y_t} + \frac{I_{f,t}}{Y_t}$, and using

models. Its advantage is that it is easy to estimate and it leads to a finite and positive steady state consumption-output ratio. Calibration models are often based on the Euler equation assuming an infinitely living representative consumer. The advantage of the latter is that in this case the model is built on structural parameters of the behavior of the representative consumer. (Chatterjee–Sakoulis–Turnovsky (2003) uses this approach when simulating the effect of capital flows on growth in open economies.) We discarded this approach because recent results in theory tell that the assumption of homogenous consumer and infinite horizon simply does not give a good description of aggregate consumption. (See Carroll (2001).) The behavior of the rich differs so much from the behavior of the poor that taking averages is not a fruitful approach. Although the interest rate does effect consumption even in the new models of consumption, the impact is so small that we took the liberty to disregard it for the sake simplicity.

$$c_t = \beta_w \frac{w_{t-1}}{1 + g_t} + \beta_y y_t^{lab}. \quad (D8)$$

In the above equation the coefficients of β_w and β_y have been calibrated in a way that the consumption ratio converges to its \bar{w} steady state value with a half-life of η ¹⁵:

$$\beta_w = 1 + \bar{r}^{pf} - (1 + \bar{g}) \exp\left(\frac{\ln 0.5}{\eta}\right) \quad (P1)$$

$$\beta_y = 1 - \left[1 - \exp\left(\frac{\ln 0.5}{\eta}\right)\right] \frac{\bar{w}}{\bar{y}^{lab}}. \quad (P2)$$

3.4 Incomes, Asset balances, Returns

$\pi_{f,t}$ and $\pi_{d,t}$ the return on capital is determined by the Cobb-Douglas consumption function by profit maximizing behavior. Production factors get a fixed share from income:¹⁶

the definition of g_t and regrouping produces the above formula.

¹⁵See the Appendix A. for a detailed derivation.

¹⁶The profit maximization condition: $\pi_{f,t} = \frac{\partial Y_t}{\partial K_{f,t-1}}$. The formula above was produced by using the definition of g_t .

$$\pi_{f,t} = (1 + g_t) \frac{\alpha_f}{k_{f,t-1}} \quad (D9)$$

$$\pi_{d,t} = (1 + g_t) \frac{\alpha - \alpha_f}{k_{d,t-1}}. \quad (D10)$$

The y_t^{lab} labor income is the rest of income after deducing capital income:

$$y_t^{lab} = 1 - \frac{\pi_{f,t} k_{f,t-1} + \pi_{d,t} k_{d,t-1}}{1 + g_t}. \quad (D11)$$

r_t^d , domestic real interest rate is determined by interest rate parity corrected for the risk premium:

$$r_t^d = \theta(q_t - q_{t+1}) + \rho_t + r^w, \quad (D12)$$

where r^w is the constant "world interest rate" ρ_t the country risk premium, q_t the real exchange rate (price of non-tradables in terms of tradables), θ a constant weight parameter that converts the change in the relative price of the two sectors into the change in the relative price of non-tradables to the aggregate of both sectors. This makes the right-hand side consistent with the definition of the real interest rate.¹⁷

The ρ_t country-risk premium depends on net financial assets (nfa_t):¹⁸

$$\rho_t = \max\{0; -\beta_\rho nfa_t\}. \quad (D13)$$

The definition of variables $\Pi_{f,t}$ and $\Pi_{d,t}$ used in equations (D6)-(D7):

$$\Pi_{f,t} = \sum_{k=t+1}^{\infty} [(\pi_{f,k} - \delta) - r_k^d] \quad (D14)$$

¹⁷In equation (D12) we approximated relative rates of changes with differences in rates.

¹⁸Debt as a risk factor may be defined in several ways. The traditional measurement is the ratio of net foreign financial assets (interest-bearing debt) to income. The alternative concept adds net real assets to the numerator. The choice depends on whether we consider real assets as a good hedge against labor income risk. In the model we followed the usual approach that considers only interest bearing debt as a risk factor.

$$\Pi_{d,t} = \sum_{k=t+1}^{\infty} [(\pi_{d,k} - \delta) - r_k^d] \quad (D15)$$

When substituting from equation (D12) we see that the investment decision depends on foreign interest rate, risk premium, and the real exchange rate as cost factors. The latter in a way that expected appreciation increases expected return.

Net foreign financial assets:¹⁹

$$nfa_t = \frac{(1 + r_t^d)nfa_{t-1} - \pi_{f,t}k_{f,t-1}}{1 + g_t} + tr_t + i_{f,t}, \quad (D16)$$

where tr_t is the trade balance, $i_{f,t} - \pi_{f,t}k_{f,t-1}/(1 + g_t)$ is the net foreign capital related flows (FDI minus profit flows).

For the sake of simplicity we assume that domestic residents do not invest directly abroad. Net wealth of the country (w_t) is then:

$$w_t = nfa_t + k_{d,t}. \quad (D17)$$

Return on net wealth is the sum of return on net financial and net real assets:

$$r_t^{pf} = \frac{(\pi_{d,t} - \delta)k_{d,t-1} + r_t^d nfa_{t-1}}{k_{d,t-1} + nfa_{t-1}}. \quad (D18)$$

Identity of the trade balance:

$$tr_t = 1 - c_t - i_{f,t} - i_{d,t}. \quad (D19)$$

3.5 The Real Exchange Rate

We assume that during the catching-up process the real exchange rate appreciates because of the

¹⁹Written in a level form: $NFA_t = (1 + r_t^d)NFA_{t-1} + TR_t + I_{f,t} - \pi_{f,t}K_{f,t-1}$. Similarly as in the equation for capital accumulation, dividing through by Y_t we arrive at: $\frac{NFA_t}{Y_t} = (1 + r_t^d) \frac{NFA_{t-1}}{Y_{t-1}} \frac{Y_{t-1}}{Y_t} + \frac{TR_t}{Y_t} + \frac{I_{f,t}}{Y_t} - \pi_{f,t} \frac{K_{f,t-1}}{Y_{t-1}} \frac{Y_{t-1}}{Y_t}$, and using the definition of g_t we get the formula above.

Balassa-Samuelson effect. The rate of this appreciation depends on the growth difference to the world rate:

$$q_{BS,t} = q_{BS,t+1} - \beta_{BS}(g_t - g^w), \quad (D20)$$

where higher $q_{BS,t}$ means appreciation and $\lim_{t \rightarrow \infty} q_{BS,t} = 1$. This constraint makes the domestic relative price equal to the world rate in steady state. The defined q_{BS} path is an equilibrium path that actual rate converges to along the path described below.

The distribution of consumer and investment demand between tradables and non-tradables is determined by maximizing a CES function:

$$\begin{aligned} \max & \left[A_{tr} (c_{tr,t} + i_{tr,t})^{-\beta_d} + A_{ntr} (c_{ntr,t} + i_{ntr,t})^{-\beta_d} \right]^{-\frac{1}{\beta_d}} \\ \text{s.t.} & (c_{tr,t} + i_{tr,t}) + q_t (c_{ntr,t} + i_{ntr,t}) = c_t + i_{f,t} + i_{d,t} \end{aligned} \quad (D21)$$

where tr and ntr subscripts denote the tradable and non-tradable sectors, β_d , A_{tr} , and A_{ntr} are parameters of the CES function. From the first order conditions:

$$q_t = \frac{A_{ntr}}{A_{tr}} \left(\frac{c_{ntr,t} + i_{ntr,t}}{c_{tr,t} + i_{tr,t}} \right)^{-\beta_d - 1}. \quad (D22)$$

Let us assume that consumers and investors CES functions are the same:

$$\frac{c_{tr,t}}{c_{ntr,t}} = \frac{c_{tr,t} + i_{tr,t}}{c_{ntr,t} + i_{ntr,t}} \quad (D23)$$

$$\frac{i_{tr,t}}{i_{ntr,t}} = \frac{c_{tr,t} + i_{tr,t}}{c_{ntr,t} + i_{ntr,t}}. \quad (D24)$$

The composition of total output in terms of tradables,

$$y_t = y_{tr,t} + q_t y_{ntr,t} \quad (D25)$$

is determined by a CET (constant elasticity of transformation) production function:

$\left[B_{tr,t} y_{tr,t}^{-\beta_s} + B_{ntr,t} y_{ntr,t}^{-\beta_s} \right]^{-\frac{1}{\beta_s}}$, where $B_{tr,t}$, $B_{ntr,t}$ are parameters changing in time and β_s is a constant

parameter. The marginal rate of transformation is equal to the real rate of exchange:

$$q_t = b_t \left(\frac{y_{ntr,t}}{y_{tr,t}} \right)^{-\beta_s-1}, \quad (\text{D26})$$

where $b_t = \frac{B_{ntr,t}}{B_{tr,t}}$.

The condition that the non-tradable market is closed:

$$y_{ntr,t} = c_{ntr,t} + i_{ntr,t}. \quad (\text{D27})$$

In the CET function the $\frac{B_{ntr,t}}{B_{tr,t}}$ ratio is not constant. The reallocation of production factors from one sector into the other may be interpreted as a change in the weighting parameters. There exists a "Balassa-Samuelson weighting parameter" path which equates the actual q_t to the $q_{BS,t}$ real exchange rate path:²⁰

$$b_t^{BS} = q_{BS,t} \left(\frac{1 - tr_t}{\left(\frac{A_{tr}}{A_{ntr}} q_{BS,t} \right)^{\frac{1}{\beta_d+1}} + tr_t q_{BS,t}} \right)^{\beta_s+1}. \quad (\text{D28})$$

Various shocks result in differences in sectoral wages and profits, but the adjustment process of factor allocation the weights of supply change and the real exchange rate converges to the Balassa-Samuelson path. We use a reduced formulation without explicitly modeling the adjustment process:

$$b_t = b_t^{BS} - \lambda_s (b_{t-1}^{BS} - b_{t-1}). \quad (\text{D29})$$

²⁰See Appendix B for the derivation.

3.6 Calibration of the Parameters

The model has 29 variables, Y_t , Y_t / Y_t^w , g_t , $k_{d,t}$, $k_{f,t}$, $i_{d,t}$, $i_{f,t}$, c_t , $\pi_{d,t}$, $\pi_{f,t}$, y_t^{lab} , r_t^d , ρ_t , $\Pi_{d,t}$, $\Pi_{f,t}$, nfa_t , w_t , r_t^{pf} , tr_t , $q_{BS,t}$, q_t , $c_{ntr,t}$, $i_{ntr,t}$, $c_{tr,t}$, $i_{tr,t}$, $y_{tr,t}$, $y_{ntr,t}$, b_t^{BS} , b_t in 29 equations. There are two additional equations that determines the values of β_w and β_y . Parameters of the model: A_0 , α , α_f , μ_{tjp} , γ , γ_{k_f} , γ_{k_d} , β_{k_f} , β_{k_d} , δ , θ , r^w , g^w , β_ρ , β_{BS} , $\frac{A_{ntr}}{A_r}$, β_d , β_s , λ_s , η , \bar{w} .

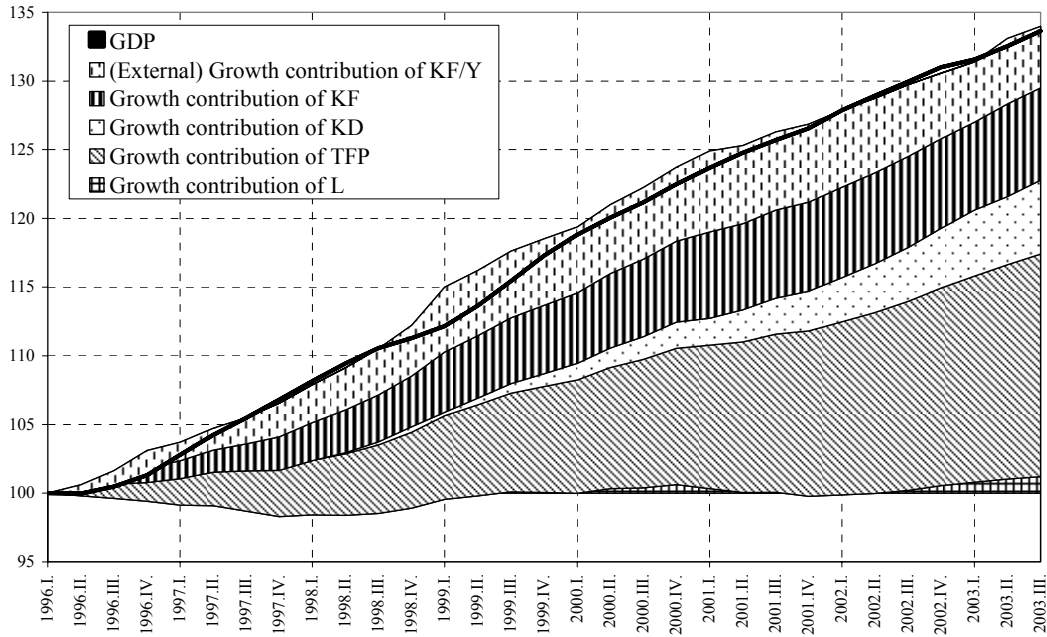
For the starting value of capital ratios we used the estimates of Darvas-Simon (1999) and Pula (2003), the share of foreign capital has been estimated from accumulating FDI data: $k_d = 1.1$, $k_f = 0.4$. The rest of stock values for the beginning of 2003 have been taken from the national income accounts: $nfa = -0.25$, and $w = 0.85$ comes from an identity. For the Y_t / Y_t^w relative level of income we assumed $Y / Y^w = 50\%$, which is our level relative to the average of the European Union.

The r^w world interest rate was taken as 4%, the depreciation rate 9%. The θ relative weight of tradables was assumed as 0.5. The coefficient of the country risk measured as the rate of debt is $\beta_\rho = 0.1$, which means that a 10 percent increase in debt raises the interest rate by 1 percentage point.²¹ The \bar{w} steady state wealth ratio was chosen by the assumption that $\bar{nfa} = 0$. The η half-life parameter is 10 years.

The production function. $A_0 = 0.932438$ was chosen that in the first year of simulation output equals 1. Capital share is the internationally usually observed $\alpha = 0.3$. Total factor productivity growth rate was calibrated in a way that in steady state growth equals the world rate, $g^w = 2\%$, therefore $\mu = (1 + \bar{g})^{1-\alpha} - 1 = 0.01396$.

²¹Edwards (1984) arrived at a half-elasticity of 0.6-1.0 in a panel estimation. At a level of about 2% this is about the corresponding figure to our linear coefficient of 0.1. Our figure is definitely more cautious than the assumed 0.4 figure in Fagan - Gaspar - Pereira (2002). The relation between risk and debt is presumably non-linear, but in our simulations we do not go as far from the base scenario to take this into account.

Figure 1. Contribution to GDP growth of production factors, exogenous TFP and externalities (1996. = 100 %) according to (D1) production function with calibrated parameters



The external effect of foreign capital was calibrated in a way that actual GDP growth should fit to the values calculated from the calibrated model in the period of 1996-2003. This criterion gave a coefficient of the external effect $\gamma = 0.4$, meaning that a 1 percent increase in the foreign capital ration increases TFP by 0.4 percentage point. This figure is higher than the 0.21 estimated by Jakab–Kovács (2002) on Central East European panel data. Barrell–Pain (1997) made estimation for Great Britain. In Great Britain the role of foreign capital as a supplier of know-how externality might be small, and the estimated coefficient reflects rather the agglomeration effect (Krugman (1991), Venables (1996)) – as it is assumed by the authors as well. Thus their coefficient of 0.27 is not comparable with our figure, especially because in our model the agglomeration effect is included in the exogenous component, while they do not specify an exogenous TFP at all.

Figure 1 shows how various components contributed to GDP growth.

We assumed that in the steady state Hungarian productivity is at the 80 percent level of the European average. This is in line with the arguments of Darvas-Simon (1999).

Investment behavior is explained in line with Tobin-q theory. In order to estimate the speed of adjustment very much empirical work can be found in the literature. The estimated

parameters are in a broad range. In the model β_{k_f} and β_{k_d} is the parameter determined by adjustment costs. Estimates in the empirical literature on the adjustment costs parameter range between 1.4 and 16.1.²² We chose a value between the two extremes, assuming $\beta_{k_f} = \beta_{k_d} = 10$.

In the real exchange rate block the Balassa-Samuelson appreciation effect of additional growth, $\beta_{BS} = 0.5$, $\frac{A_{nr}}{A_r} = 1$. We chose the exchange rate elasticities of demand and supply, $\beta_d = 2$, $\beta_s = -3$ to make a 1 percentage point deterioration of the trade balance consistent with a 2 percent appreciation of the real exchange rate. This number is in line with the estimations of Jakab–Kovács (2002) for exports and imports. At the starting date the real exchange rate is in equilibrium by assumption. This assumption is indifferent for the policy lessons derived from the model and it has no relevance to the actual real exchange rate either, as the real exchange rate in our model is the rate of the hypothetical case when the output gap equals 0. In the short run, for example during a disinflation process this assumption is probably untenable.

In the supply function the λ_s parameter that determines the speed of adjustment across sectors was chosen to be consistent with the 5 years half-life of the convergence to the Balassa-Samuelson equilibrium, $\lambda_s = 0.87055$.

In Table 1 we summarized the assumptions on parameters, starting values, and the implied steady state values.

²²Summers (1981) estimated a value of 16.1, Eberly (1997) arrived at a range of 1.4 and 3 using micro data. Cummins–Hasset–Oliner (1997) using US firm data estimated parameters between 5 and 10.

Table 1 Parameters, Starting and Steady State Values

Parameters			Calculated coefficients		
η	=	10	β_y	=	0.70981
\overline{w}	=	1.56923	β_w	=	0.16204
α	=	0.3			
α_f	=	0.1			
γ	=	0.4			
μ^{tfp}	=	0.01396			
β_{k_f}	=	10			
β_{k_d}	=	10			
δ	=	0.09			
θ	=	0.5	Steady state values		
r^w	=	0.04	\overline{r}^d	=	0.05
g^w	=	0.02	\overline{g}	=	0.02
β_ρ	=	0.1	$\overline{\rho}$	=	0
β_{BS}	=	0.5	\overline{c}	=	0.74615
$\frac{A_{ntr}}{A_{tr}}$	=	1	$\overline{i}_f + \overline{i}_d$	=	0.23077
β_d	=	2	\overline{tr}	=	0.02308
β_s	=	-3	\overline{y}^{lab}	=	0.7
λ_s	=	0.5	$\overline{\pi}$	=	0.13
			\overline{r}^{pf}	=	0.05
Starting values					
k_d	=	1.1	\overline{k}_d	=	1.56923
k_f	=	0.4	\overline{k}_f	=	0.78461
nfa	=	-0.25	\overline{nfa}	=	0
Y/Y^w	=	0.5	$\overline{Y/Y^w}$	=	0.77172

4 Simulations

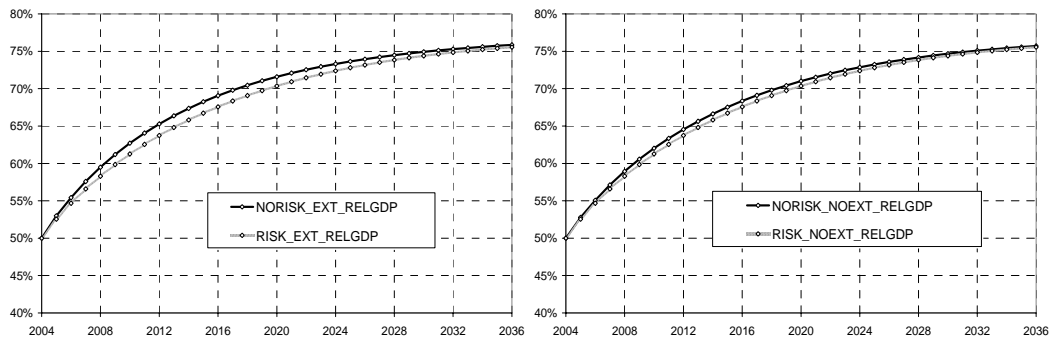
4.1 Catching-up paths

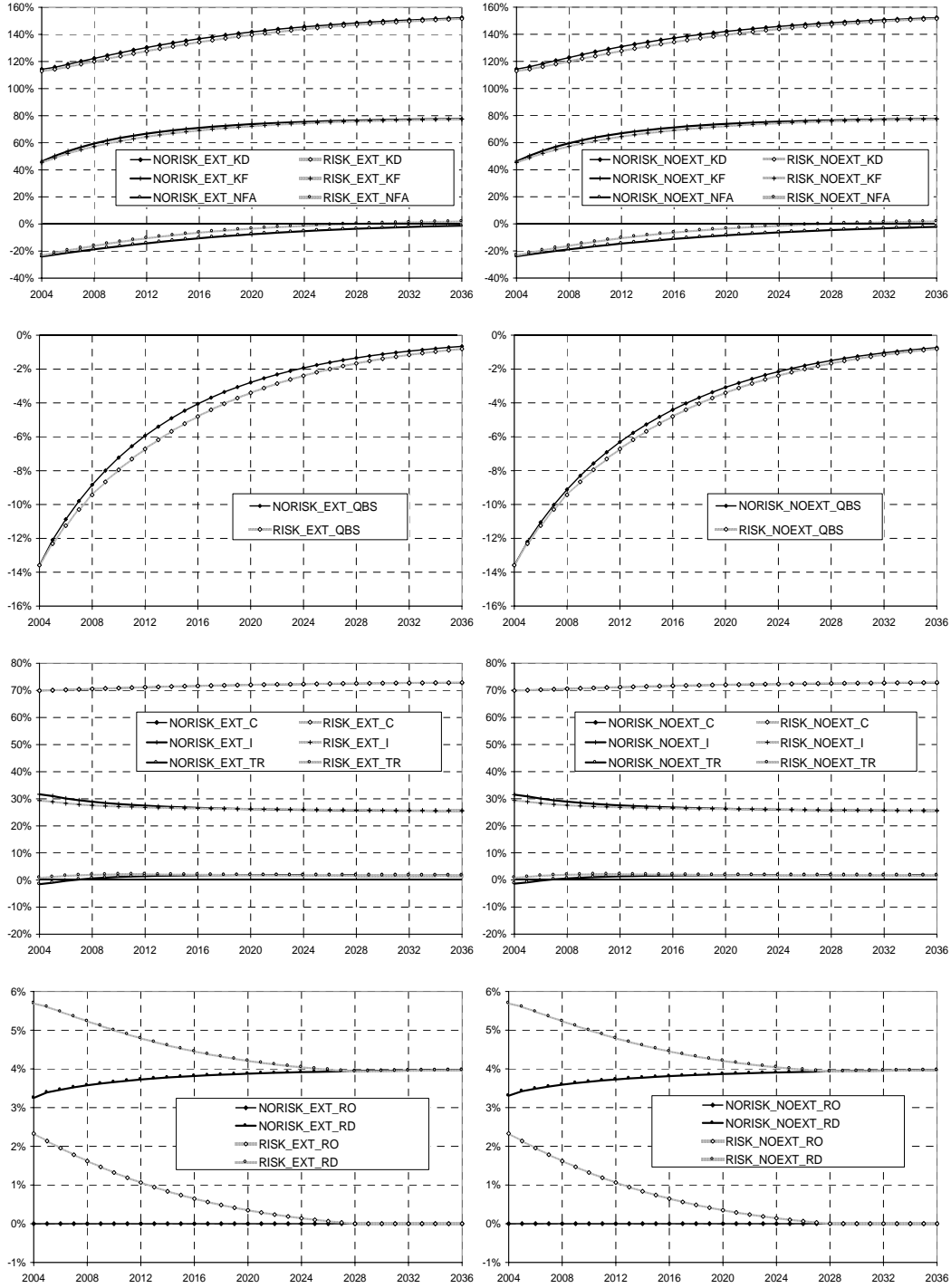
First we show the growth (catching-up) paths implied by the parameters of Table 1. We calculate 4 alternative scenarios. In the case that we consider the most probable both the externality of foreign capital and the risk premium are important factors. In the other variants we show what will happen if one of the two factors or both are omitted. With showing the alternatives we try to give a picture of the sensitivity of the results on the critical assumptions of the model.

In the first column we show the paths calculated on the assumption that foreign capital has an external effect. The two paths differ on the assumption whether indebtedness increased the risk premium. In the absence of a risk premium the catching-up process is faster.

In the second column we calculated with a model where productivity growth is entirely exogenous. This exogenous productivity growth is equal to the sum of exogenous and externalities driven growth calculated in the baseline case where both externalities and risk premium exist. Here again the existence of risk constrains the speed of catching-up. However, as in this case the role of foreign capital is minor, the existence of the risk premium does not make much difference.

Figure 2 Catching-up paths in four variants





Remark. In the right hand side column the assumption holds that foreign capital has an external effect, while in the left hand side column this assumption is dropped. Black curves indicate variants where endogenous risk premium is absent, while gray curves show variants with an endogenous risk premium.

4.2 Effects of Consumption Shocks

None of the four paths can be interpreted as an optimum in the sense that it maximizes the value of consumer utility functions. We discarded this approach when bringing the consumption function from outside into the model. We could have chosen to calculate the intertemporal optimum with a representative consumer or a social preference function in mind, then calculate a "suboptimum" as the solution of the decentralized task with the distortions created by externalities and calculate the optimal tax system that leads to the social optimum. Although we do not deny that the theoretical rigor of this approach is a merit we believe that the parameters of a social preference function are rather uncertain and therefore a model used for drawing policy lessons is probably better if it is simple but its results easier to interpret. Therefore we simply made a present value calculation answering the question what is the intertemporal rate of substitution at the baseline path between consumption today and tomorrow.

The consumption shocks need not be interpreted as fiscal consumption shocks. However, if we want to draw policy conclusions it is natural to consider them as consumption shocks forced out by fiscal policy. It is reasonable to assume this possibility because riparian equivalence exists only in the infinite horizon representative consumer case.

We calculated the effect of two kinds of shocks:

- 1) In a transitory consumption shock the consumption ratio increases by 1 percentage point in the first period (year) but the steady state wealth ratio does not change.
- 2) In a permanent consumption shock the consumption ratio increases by 1 percentage point in the first period (year) and the steady state wealth ratio decreases by the same 1 percentage point.

The consumption shock exerts its effect through the following channels. A transitory shock increases demand, that appreciates the currency and – because of the interest rate parity – it raises the interest rate. At the same time interest rates are affected by the resulting increase in the risk premium. The higher interest rate decreases expected net profits and investments will be lower, including FDI which decreases productivity growth. Later consumption adjusts to meet the targeted wealth ratio and investments rebound to put the economy to the original steady state level. In case of a permanent shock the targeted wealth ratio is lower which means a permanently higher risk premium and lower output and productivity level in the steady state.

A summary indicator of the effect of the shock is the internal interest rate that when used as a discount factor the present value of future foregone consumption equal to the gain in present consumption, or putting in another way the sum of differences to the baseline in consumption flows equal to 0. As Table 2 shows, if we do not believe in externalities and risk premium, we arrive at a 4.2%–5.0% interest rate which is significantly higher than the world real interest rate adjusted with the Balassa-Samuelson effect,²³ but not as high that could not easily be explained with a high time preference. However, if we assume the existence of a risk premium, the implicit interest rate increases over 7.4 percent, and the inclusion of externalities brings the interest rate to the level of 17.2-18.1. This is a shockingly high rate, higher than anything observed normally on markets

Table 2 Implicit interest cost (return of aggregate saving) at the present level of indebtedness

	With foreign capital externalities		Without foreign capital externalities	
	With risk premium	Without risk premium	With risk premium	Without risk premium
Transitory shock	17.2%	6.3%	10.0%	5.0%
Permanent shock	18.1%	5.1%	7.4%	4.2%

We tested the robustness of the results in a sensitivity analysis. We changed the parameter values by 50 percent one by one and calculated the results again. The differences from the baseline are shown in Table 3.

As we see for most of the parameters even a 50 percent change does not result a change higher than 1 percent in the internal interest rate. In the variants without country risk premium the sensitivity is even lower. The parameters that have the highest effect on the interest rate are the parameters influencing capital accumulation and productivity directly, like γ , the external effect of foreign capital, β_{kd} and β_{kf} , the adjustment costs of investment, and β_p the risk premium coefficient. Even these parameters cause changes in the range of 2 percentage points only and the highest value is 3.2 percentages.

Summing up the results from the sensitivity analysis we can say that the figures in Table 2

²³In the presence of the Balassa-Samuelson effect real interest rate parity holds only in terms of the tradable sector, while the basket will appreciate.

are robust, the conclusions do not change qualitatively even if some parameters change considerably.

Table 3 Analysis of Parameter sensitivity
Implicit interest costs of a unit change in consumption, difference from the baseline

		Transitory shock				Permanent shock			
		With foreign capital externalities		Without foreign capital externalities		With foreign capital externalities		Without foreign capital externalities	
		With risk premium	Without risk premium	With risk premium	Without risk premium	With risk premium	Without risk premium	With risk premium	Without risk premium
$\eta = 10$	$\eta = 5$	-0,7%	1,1%	0,2%	1,4%	-0,7%	-0,1%	-0,6%	0,0%
	$\eta = 15$	0,4%	-0,5%	0,1%	-0,5%	0,3%	0,0%	0,4%	0,0%
$\gamma = 0,4$	$\gamma = 0,3$	-1,6%	-0,5%	0,1%	0,1%	-2,5%	-0,2%	0,0%	0,1%
	$\gamma = 0,5$	1,7%	0,6%	0,0%	-0,1%	2,6%	0,3%	0,0%	-0,1%
$\beta_{kf} = \beta_{kd} = 10$	$\beta_{kf} = \beta_{kd} = 5$	2,1%	1,3%	0,8%	0,1%	1,3%	0,5%	0,5%	0,0%
	$\beta_{kf} = \beta_{kd} = 15$	-1,4%	-0,5%	-0,6%	0,0%	-0,9%	-0,2%	-0,4%	0,0%
$\rho = 0,09$	$\rho = 0,08$	0,2%	0,1%	-0,1%	0,0%	0,6%	0,0%	-0,1%	0,0%
	$\rho = 0,10$	-0,2%	-0,1%	0,1%	0,0%	-0,5%	0,0%	0,1%	0,0%
$r_w = 0,04$	$r_w = 0,03$	-0,5%	-0,9%	-1,1%	-1,1%	-0,1%	-1,6%	-1,2%	-1,5%
	$r_w = 0,05$	0,6%	0,9%	1,1%	1,1%	0,2%	1,3%	1,2%	1,2%
$\beta_p = 0,1$	$\beta_p = 0,05$	-3,0%	0,0%	-1,6%	0,0%	-3,2%	0,0%	-1,1%	0,0%
	$\beta_p = 0,15$	2,2%	0,0%	1,4%	0,0%	2,0%	0,0%	0,8%	0,0%
$g = 0,02$	$g = 0,01$	-0,1%	0,1%	0,1%	0,2%	-0,1%	0,4%	0,2%	0,3%
	$g = 0,03$	0,1%	-0,1%	-0,1%	-0,2%	0,1%	-0,7%	-0,2%	-0,5%
$\beta_{bs} = 0,5$	$\beta_{bs} = 0,25$	0,3%	0,4%	0,3%	0,3%	0,0%	0,2%	0,1%	0,1%
	$\beta_{bs} = 0,75$	-0,3%	-0,5%	-0,3%	-0,3%	0,0%	-0,2%	-0,1%	-0,1%
$A_{ntr}/A_{tr} = 1$	$A_{ntr}/A_{tr} = 0,5$	-0,2%	-0,3%	-0,2%	-0,2%	-0,1%	-0,1%	0,0%	-0,1%
	$A_{ntr}/A_{tr} = 1,5$	0,2%	0,2%	0,1%	0,1%	0,1%	0,1%	0,0%	0,0%
$\beta_d = 2$	$\beta_d = 1$	-0,4%	-0,5%	-0,3%	-0,3%	-0,2%	-0,2%	-0,1%	-0,1%
	$\beta_d = 3$	0,3%	0,3%	0,2%	0,2%	-0,1%	-0,1%	0,0%	-0,1%
$\beta_s = -3$	$\beta_s = -4$	0,6%	0,8%	0,5%	0,5%	0,3%	0,4%	0,1%	0,1%
	$\beta_s = -2$	-1,1%	-1,4%	-0,9%	-0,8%	-0,4%	-0,5%	-0,2%	-0,2%
$\theta = 0,5$	$\theta = 0,25$	-1,4%	-1,7%	-1,1%	-1,0%	-0,7%	-0,6%	-0,2%	-0,2%
	$\theta = 0,75$	1,2%	1,4%	0,9%	0,8%	0,6%	0,7%	0,2%	0,2%
$\lambda_s = 0,87055$	$\lambda_s = 0,75786$	-0,1%	0,2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	$\lambda_s = 0,91172$	0,1%	-0,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

In the individual lines all parameters are the same as in the baseline except the parameter indicated.

(For the values of 0.87055; 0.75786 and 0.91172 for λ_s the corresponding half-lives are 5; 2.5 and 7.5 years.)

5 Summary and Assessment

Fiscal discipline has a large role in the real convergence process of Central East European Countries. Fiscal policy aimed at cutting indebtedness by restraining consumption creates higher macroeconomic stability and an incentive for investors. This attracts foreign investment in a period when this increases productivity through external effects. Estimates of the model show that additional saving may bring an 18 percent return for consumers.

This rate is higher than any reasonable market rate but it is not surprising when the external effects incorporated into the model are considered. The question to put is whether this rate is consistent with the preferences of society? Is it reasonable that the government does not decide to increase savings if additional saving brings 18 percent real yield?

We know that the social utility function is not the sum of individual utility functions. Part of the population has a very high time preference,²⁴ resulting in a behavior that considers savings at best as a buffer stock against short run losses in income. Some of these "liquidity constrained" consumers is willing to take loans at a real rate of even higher than 18 percent. These consumers might be satisfied with a policy strategy that reallocates future consumption into the present at an opportunity cost of 18 percent. However it is questionable whether it was reasonable to call such a policy as serving social welfare. Namely there are many who would consider a borrowing on 18 percent interest as unreasonable. However, as this interest rate is not internalized for them, they do not have the chance of a direct free choice in making such a return by saving.

In this paper we did not discuss how the government could internalize this return. We set the task only to calculate the magnitude of this return to allow policy makers to make choices on the basis of correct information.

²⁴The idea of a high rate of time preference has come up at Friedman (1957) already, and Carroll (1992) was one of those who contributed most to the rigorous analysis of the consequences. Empirical econometric models use mostly the related concept of Mankiw who considers the majority of consumers as liquidity constrained, consuming as much as they earn. (The fiscal implications of this behavior are discussed in Mankiw (2000).)

References

- Alesina, A., – Ardagna, S. (1998): Tales of Fiscal Adjustment, *Economic Policy*, pp. 488-545.
- Blanchard, O. (1990): Comments on Gavazzi and Pagano, in *NBER Macroeconomics Annual 1990*, O. Blanchard–S. Fisher eds, Cambridge, MA: MIT Press.
- Barrell, R. –Pain, N. (1997): Foreign Direct Investment, Technological Change and Economic Growth within Europe, *The Economic Journal*, 107, pp. 1770-86.
- Chatterjee, S. – Sakoulis, G. – Turnovsky, S. J. (2003): Unilateral Capital Transfers, Public Investment, and Economic Growth, in *European Economic Review*, 47, 1077-1103.
- Carroll, C. D. (1992): The Buffer-Stock Theory of Saving: Some Macroeconomic Evidence, *Brookings Papers on Economic Activity*, 1992(2), 61-156.
- Carroll, C. D. (2001): Death to the Log-Linearized Consumption Euler Equation! (And Very Poor Health to the Second Order Approximation), *Advances in Macroeconomics*, 1(1), <http://www.bepress.com/bejm/advances/voll/iss1/art6>.
- Cummins, J. – Hassett, K. – Oliner, S. (1999): Investment Behavior, Observable Expectations, and Internal Funds, Finance and Economics Discussion Series, 1999/27, Board of Governors of the Federal Reserve System.
- Darvas, Zs. – Simon, A. (2000): Capital Stock and Economic Development in Hungary, *Economics of Transition*, 8(1), pp. 197-223.
- Dornbusch, R. (1980): *Open Economy Macroeconomics*, Basic Books, New York.
- Eberly, J. (1997): International Evidence on Investment and Fundamentals, *European Economic Review*, Vol. 41 pp. 1055-78.
- Edwards, S. (1984): LDC Foreign Borrowing and Default Risk: An Empirical Investigation, 1976-80, *The American Economic Review*, 74/4, pp 726-734.
- Fagan, G. – Gaspar, V. – Pereira, A. (2002): Macroeconomic Adjustment to Structural Change, paper presented at the Seminar "Monetary Strategies for Accession Countries", Budapest, February 27-28.

- Faruquee, H. (1995): Long-Run Determinants of the Real Exchange Rate: A Stock-Flow Perspective, *IMF Staff Papers*, Vol 42, pp. 80-107.
- Feldstein, M. and C. Horioka (1980): Domestic Saving and International Capital Flows, *Economic Journal*, pp. 314-329.
- Friedman, M. (1957): A Theory of Consumption Function, Princeton University Press.
- Harberger, A. C. (1986): Welfare Consequences of Capital Inflows, in A. Choksi and D. Papageorgiou, eds: *Economic Liberalization in Developing Countries*, Basil Blackwell, Oxford.
- Jakab, M. Z. – Kovács, M. A. (2002) Hungary in the NIGEM Model. *Working paper*, Magyar Nemzeti Bank, 2002/3.
- Krugman, P. (1991): Globalisation and the Inequality of Nations, *Quarterly Journal of Economics*, 110, pp. 857-80
- Mankiw, G. (2000): The Savers-Spenders Theory of Fiscal Policy, *American Economic Review* 90, May 2000, 120-125.
- Perotti, R. (1999): Fiscal Policy in Good Times and Bad, *Quarterly Journal of Economics*, 114, pp. 1399-1436.
- Pula Gábor (2003): A tőkeállomány becslése Magyarországon PIM módszerrel. Módszertani leírás és eredmények. *MNB Füzetek*, 2003/7.
- Rogoff, K. (1996): The Purchasing Power Parity Puzzle, *Journal of Economic Literature* 34(2) 647-668.
- Romer, P. M. (1986): Increasing Returns and Long Run Growth, *Journal of Political Economy*, 98: 71-102.
- Simon, A. – Várpalotai, V. (2001): Optimal Indebtedness of a Small Open Economy with Precautionary Behavior, *Working paper 2001/1*, Magyar Nemzeti Bank.
- Stein, J. L. (1999): The Evolution of the US Dollar Relative to the G7 Currencies in R. McDonald – J. Stein (eds), *Equilibrium Exchange Rates*, Amsterdam: Kluwer.
- Summers, L. H. (1981): Taxation and Corporate Investment: a q-theoretic approach, Brookings

Papers on Economic Activity: I, Brookings Institution, pp. 67-127.

Valentinyi, Á. (2000): Gazdasági növekedés, felzárkózás és költségvetési politika egy kis, nyitott gazdaságban, *Közgazdasági Szemle*, XLVII/6, 391-410.

Venables, A. J. (1996): Localization of Industry and Trade Performance, *Oxford Review of Economic Policy*, 12(3), pp. 52-60.

Appendix A: Derivation of the Parameters in the Consumption Function

In the $c_t = \beta_w w_{t-1} / (1 + g_t) + \beta_y y_t^{lab}$ consumption function β_w and β_y have been determined by the constraint that consumption should converge to a \bar{w} steady state wealth ratio with η half-life. Let us first write the equation for w_t wealth accumulation, using

$k_{d,t} = \frac{1-\delta}{1+g_t} k_{d,t-1} + i_{d,t}$ and $nfa_t = \frac{(1+r_t^d)nfa_{t-1} - \pi_{f,t}k_{f,t-1}}{1+g_t} + tr_t + i_{f,t}$ equations.²⁵ Thus:

$$nfa_t + k_{d,t} = \frac{(1+r_t^d)nfa_{t-1} - \pi_{f,t}k_{f,t-1}}{1+g_t} + tr_t + i_{f,t} + \frac{1-\delta}{1+g_t} k_{d,t-1} + i_{d,t},$$

and by using definitions $tr_t = 1 - c_t - i_{f,t} - i_{d,t}$ and $y_t^{lab} = 1 - \frac{\pi_{f,t}k_{f,t-1} + \pi_{d,t}k_{d,t-1}}{1+g_t}$ – equations (D11) and (D19) –, after rearranging:

$$nfa_t + k_{d,t} = \frac{(1+r_t^d)nfa_{t-1} + (1+\pi_{d,t}-\delta)k_{d,t-1}}{1+g_t} + [y_t^{lab} - c_t],$$

and by substituting r_t^{pf} and the definition of the wealth ratio ($w_t = nfa_t + k_{d,t}$) we get

$$w_t = \frac{1+r_t^{pf}}{1+g_t} w_{t-1} + [y_t^{lab} - c_t]$$

The consumption block in a narrow sense is a difference equation system for c_t and w_t :

$$c_t = \beta_w \frac{w_{t-1}}{1+g_t} + \beta_y y_t^{lab}$$

$$w_t = \frac{1+r_t^{pf}}{1+g_t} w_{t-1} + [y_t^{lab} - c_t]$$

After substituting c_t into the second equation and rearranging:

²⁵See equations (D6) and (D16).

(F1)

$$w_t = \frac{1 + r_t^{pf} - \beta_w}{1 + g_t} w_{t-1} + (1 - \beta_y) y_t^{lab}.$$

Disregarding from the interaction among y_t^{lab} , g_t , r_t^{pf} and w_t around steady state the half-life of the differential equation is determined by $\frac{1 + \bar{r}^{pf} - \beta_w}{1 + g}$. If we want to calibrate the model to a given η half life, then by determining β_w from $\frac{1 + \bar{r}^{pf} - \beta_w}{1 + g} = \exp\left(\frac{\ln 0.5}{\eta}\right)$ we get the (P1) formulation. From a given \bar{w} we can express β_y from equation (F1), because $\bar{w} = \exp\left(\frac{\ln 0.5}{\eta}\right) \bar{w} + (1 - \beta_y) \bar{y}^{lab}$, and by rearranging we get the form (P2) that determines β_y .

Appendix B: Derivation of the Equations in the Real Exchange Rate Block

We give here the derivation of equation (D28) that determines the b_t changing variable. Let us write $q_{BS,t}$ everywhere instead of q_t and replace $c_{ntr,t} + i_{ntr,t}$ in equation (D22) by the accounting identity (D27), and substitute the budget constraint of consumption and investment (D21) for $c_{tr,t} + i_{tr,t}$:

$q_{BS,t} = \frac{A_{ntr}}{A_{tr}} \left(\frac{y_{ntr,t}}{c_t + i_t - q_{BS,t} y_{ntr,t}} \right)^{-\beta_d - 1}.$	(D30)
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Rearranging for $y_{ntr,t}$ and using $c_t + i_t = 1 - tr_t$:

$y_{ntr,t} = \frac{1 - tr_t}{\left(\frac{A_{tr}}{A_{ntr}} q_{BS,t} \right)^{\frac{1}{\beta_d + 1}} + q_{BS,t}}.$	(D31)
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In equation (D26) by using equation (D25) we write $1 - q_{BS,t} y_{ntr,t}$ instead of $y_{tr,t}$ and plugging in for $y_{ntr,t}$:

$q_{BS,t} = b_t \left(\frac{\frac{1-tr_t}{\left(\frac{A_{tr}}{A_{ntr}} q_{BS,t}\right)^{\frac{1}{\beta_{d+1}}} + q_{BS,t}}}{1 - q_{BS,t} \frac{1-tr_t}{\left(\frac{A_{tr}}{A_{ntr}} q_{BS,t}\right)^{\frac{1}{\beta_{d+1}}} + q_{BS,t}}} \right)^{-\beta_s-1} .$	(D32)
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Expressing b_t and rearranging we get the formula (D28).

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